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(54) Abstract Title
Structural sandwich plate members

(57) A structural sandwich plate member (2) formed of outer metal plates (3) and a plastics or polymer core (4) such as an elastomer which bonds the outer metal plates together with sufficient strength to transfer shear forces therebetween has a hollow member (1) embedded in the core to define a void within the core. The hollow member may comprise one or more elongate tube like portions (11). Elongate tube like portions may be joined together by webs (12) with additional webs (13) projecting from the outer sides of outer tube-like portions. The tube-like portions may have internal reinforcing ribs and vertical spacing webs. The hollow member may be adapted for the use of corrugated outer metal plates.

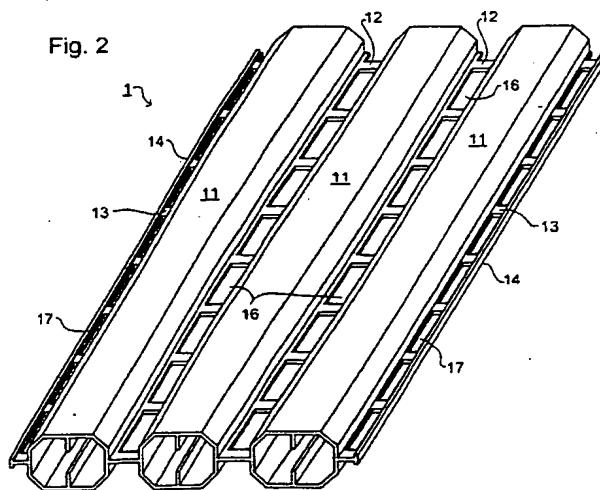
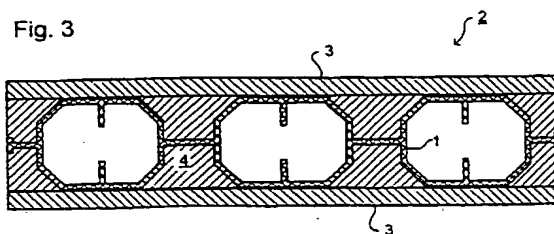


Fig. 3



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Fig. 1

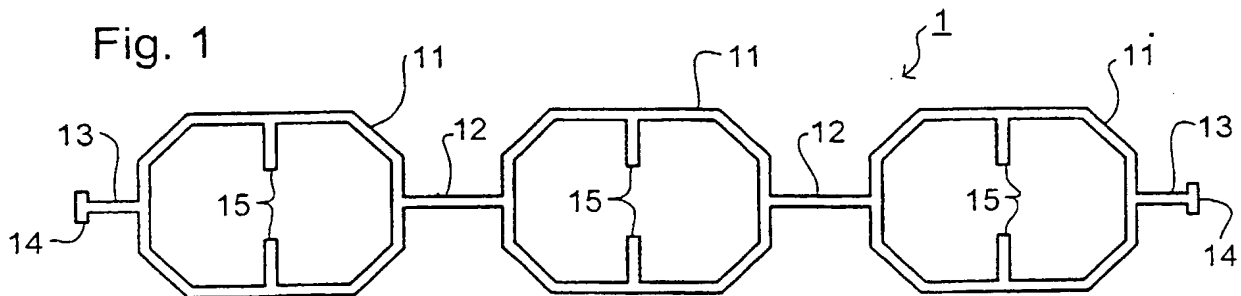


Fig. 2

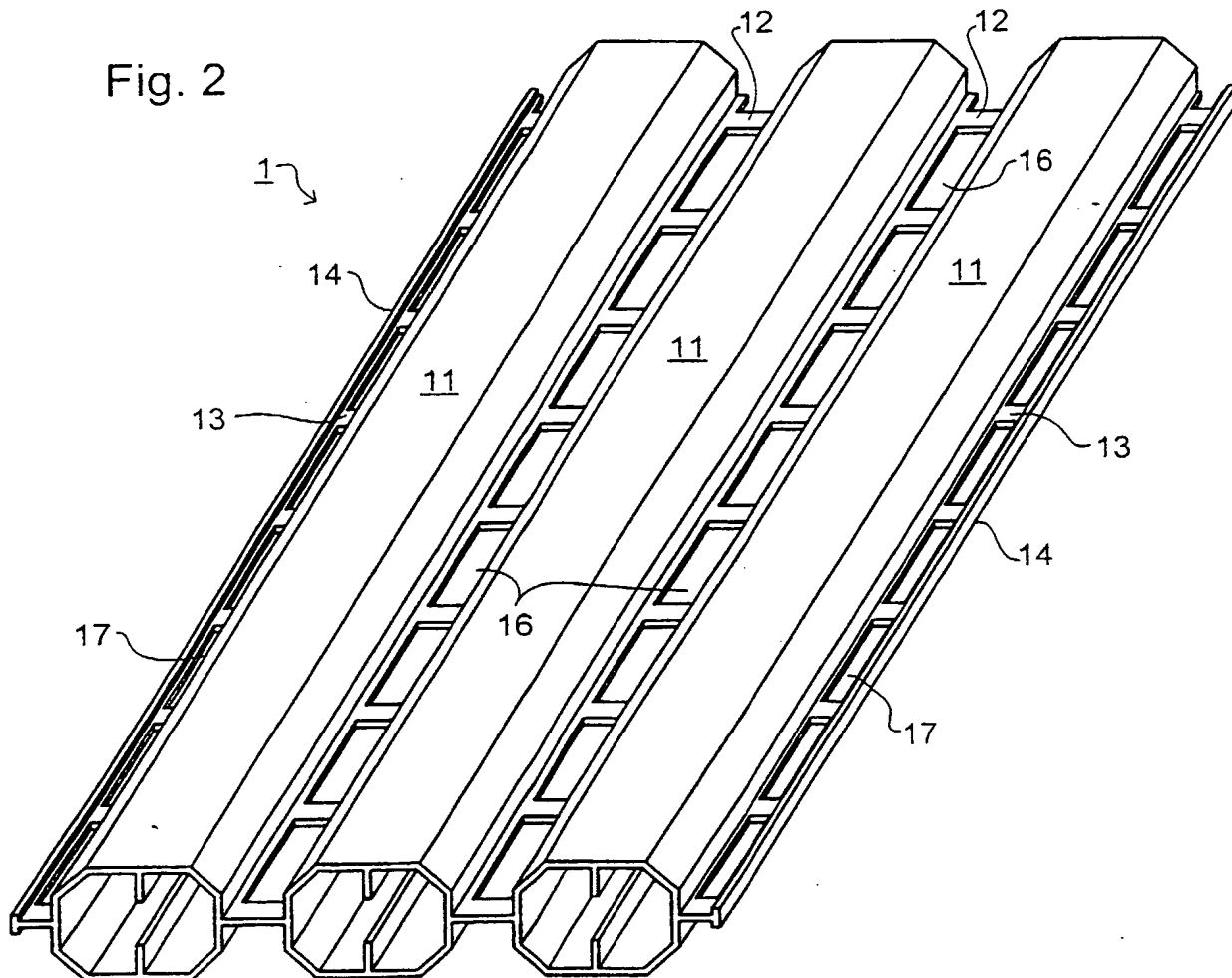


Fig. 3

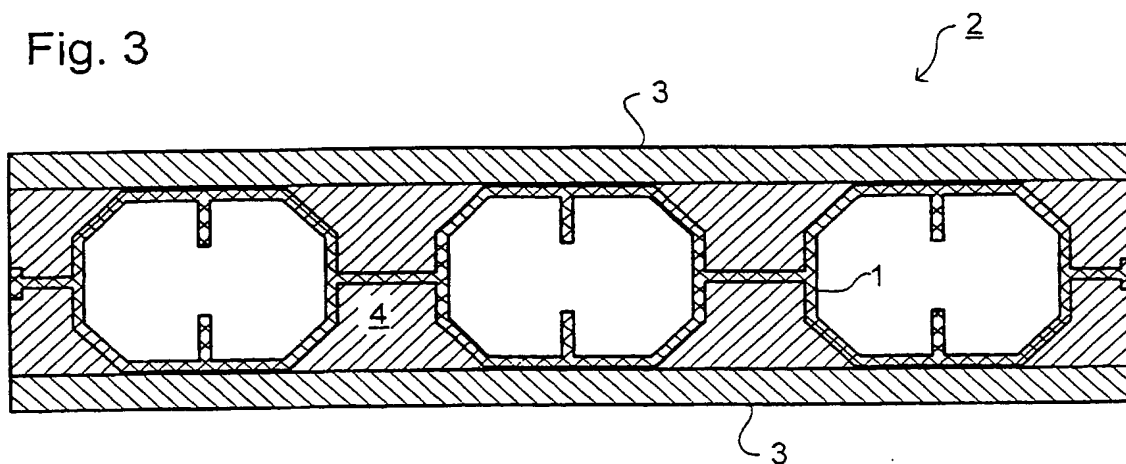


Fig. 4

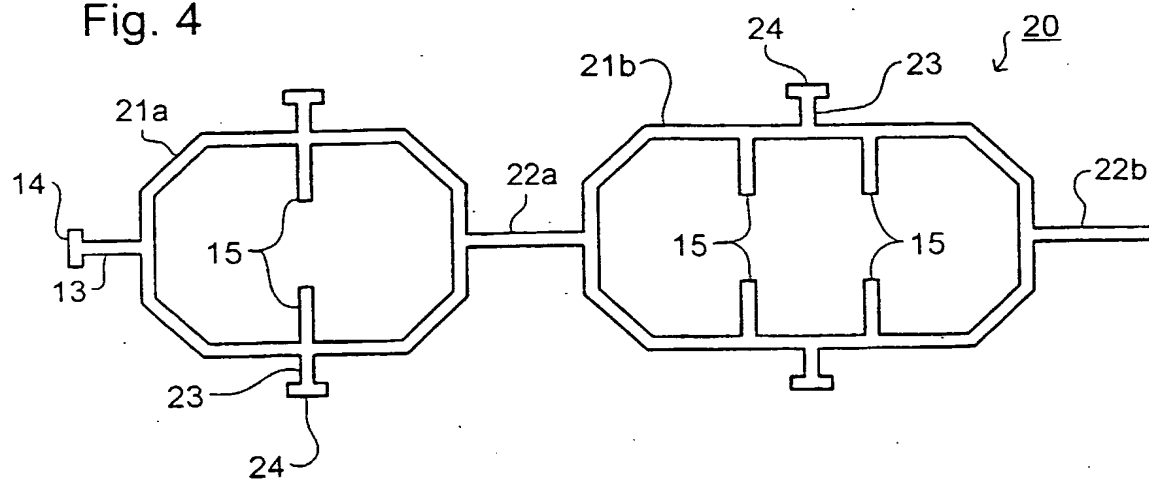


Fig. 5

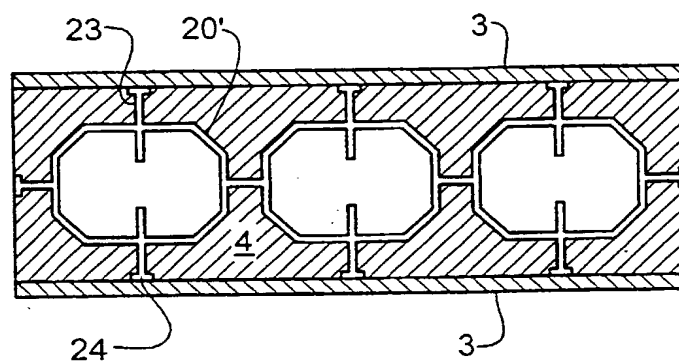


Fig. 6

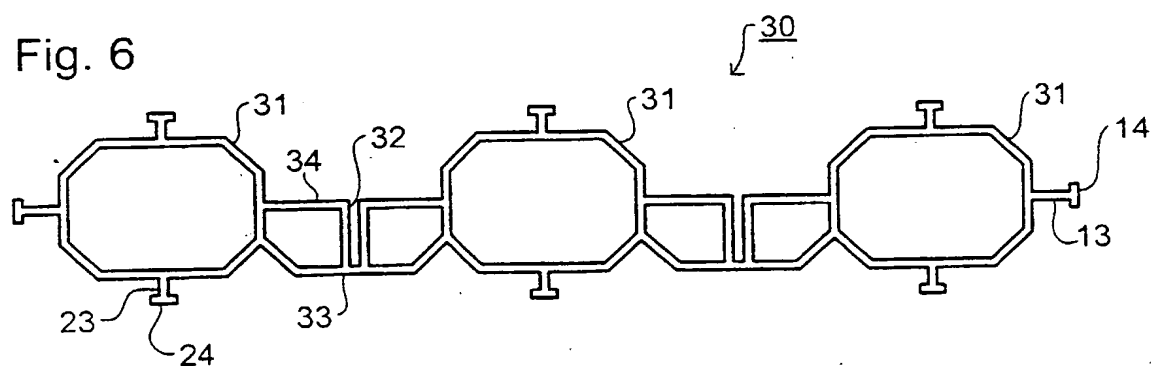


Fig. 7

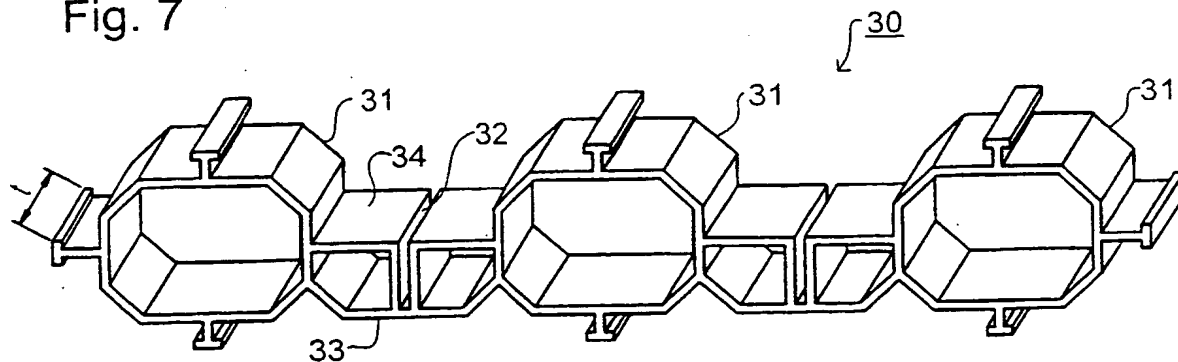


Fig. 8

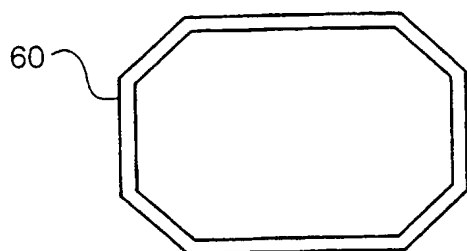


Fig. 9

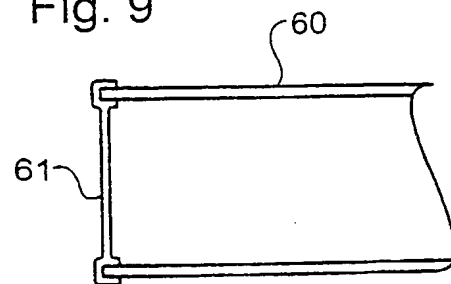


Fig.10

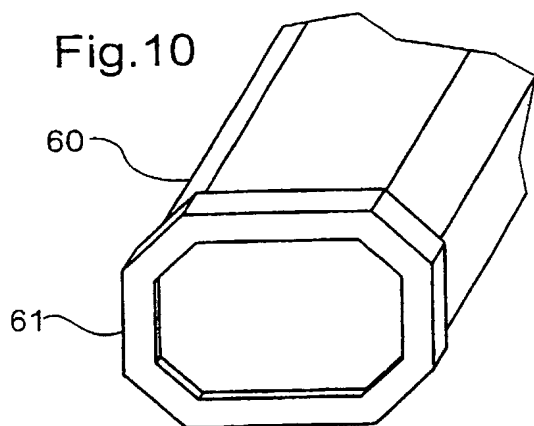


Fig.11

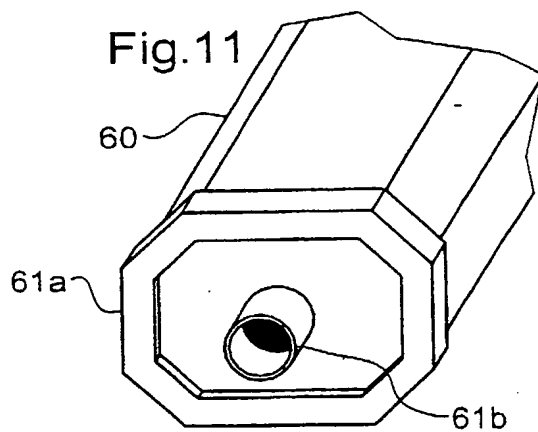


Fig.12

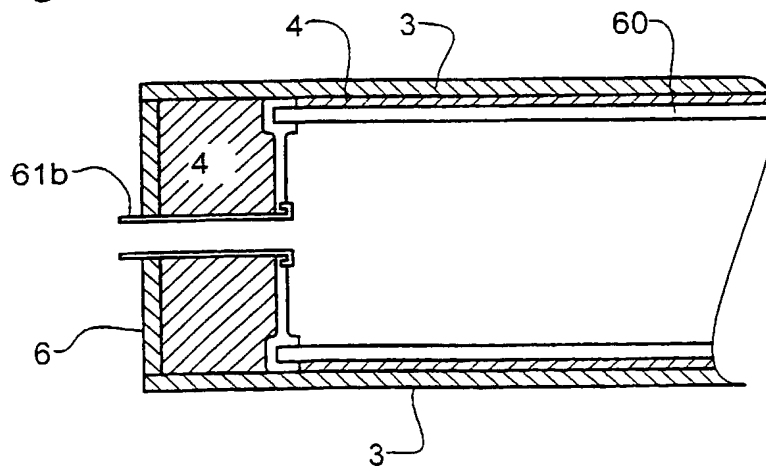


Fig. 13

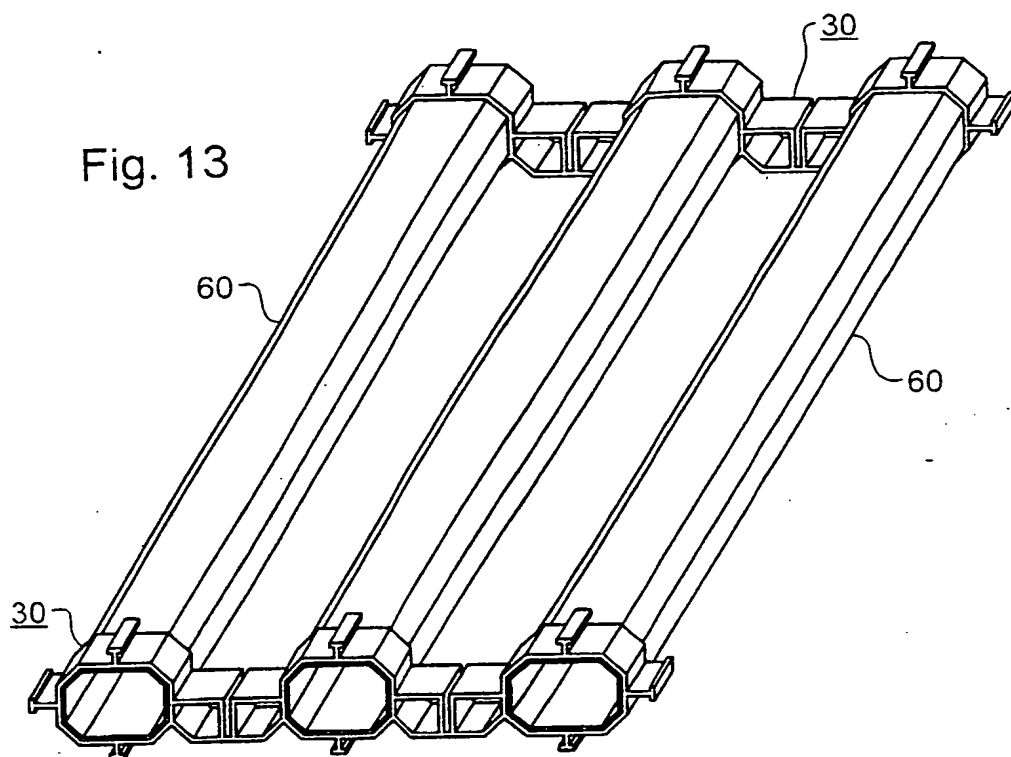


Fig. 14

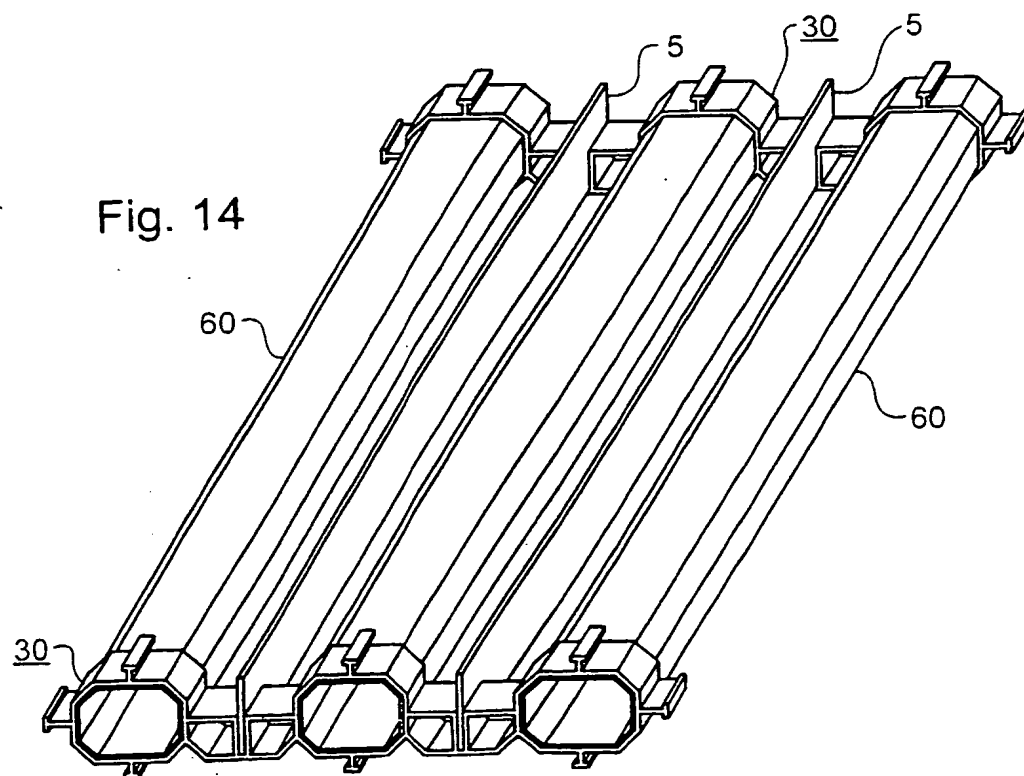


Fig. 15

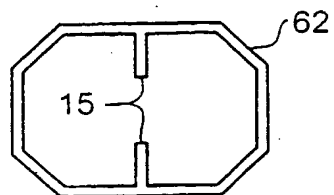


Fig. 16

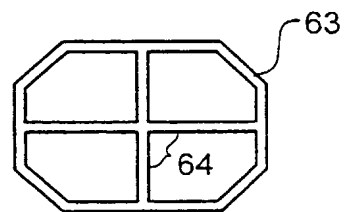


Fig. 17

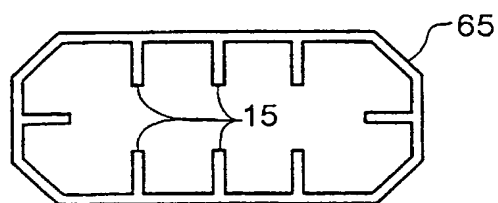


Fig. 18

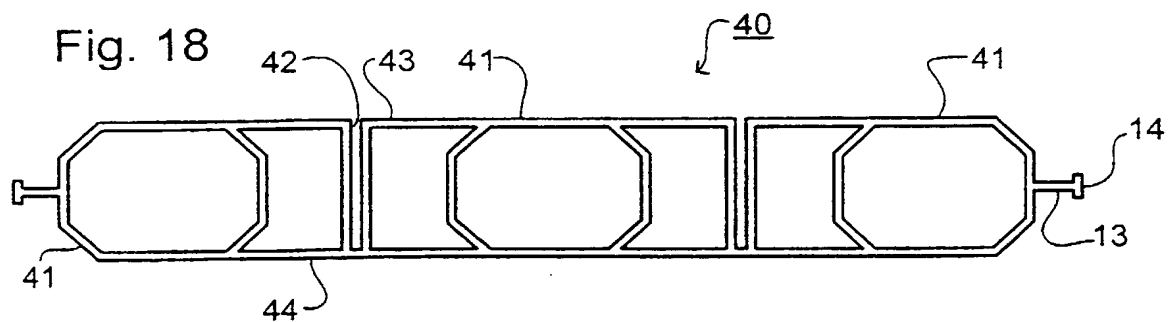


Fig. 19

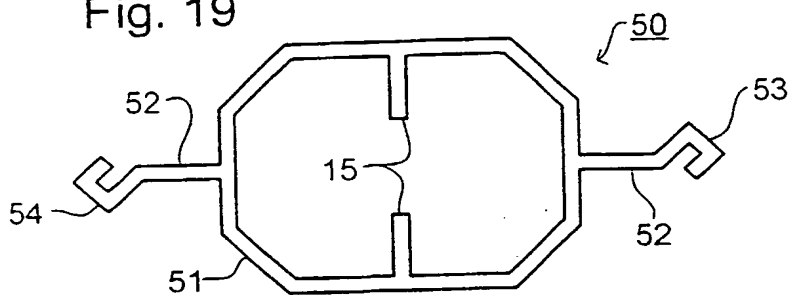


Fig. 20

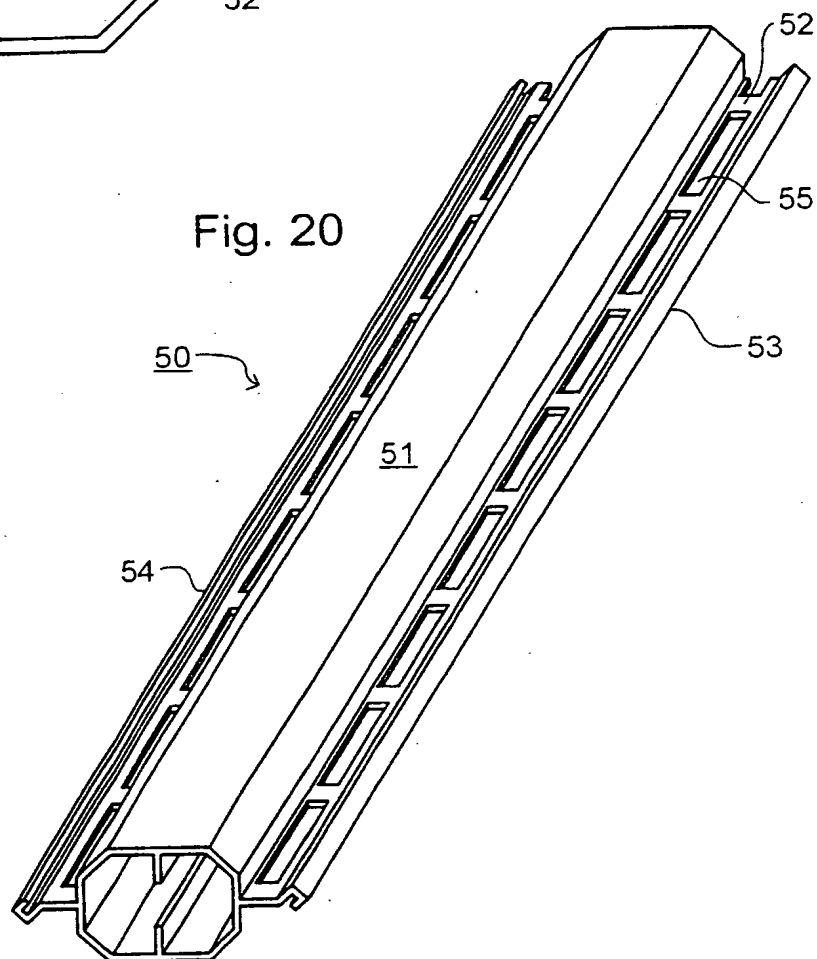


Fig. 21

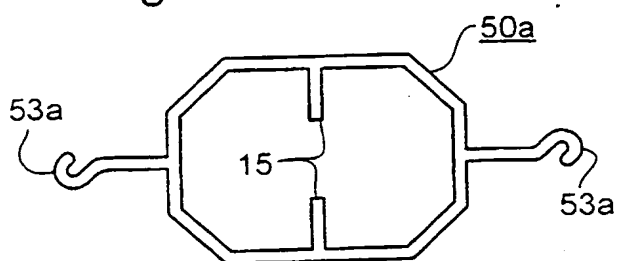


Fig. 22

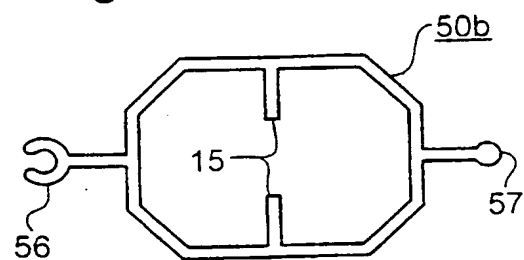


Fig. 23

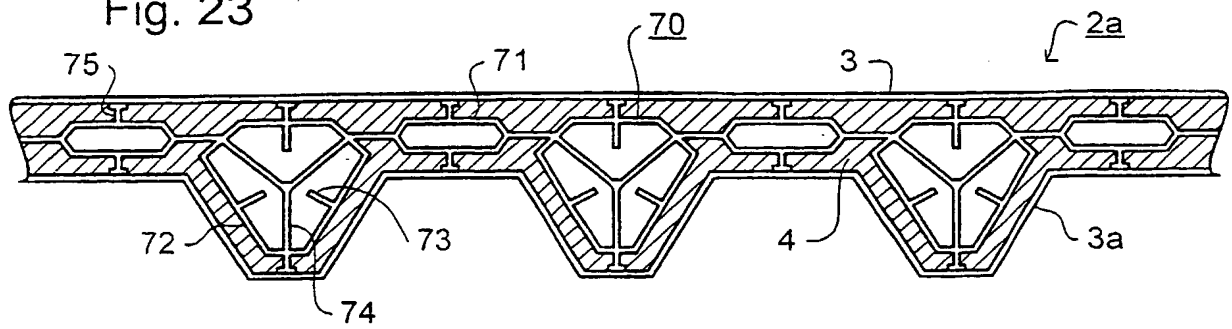
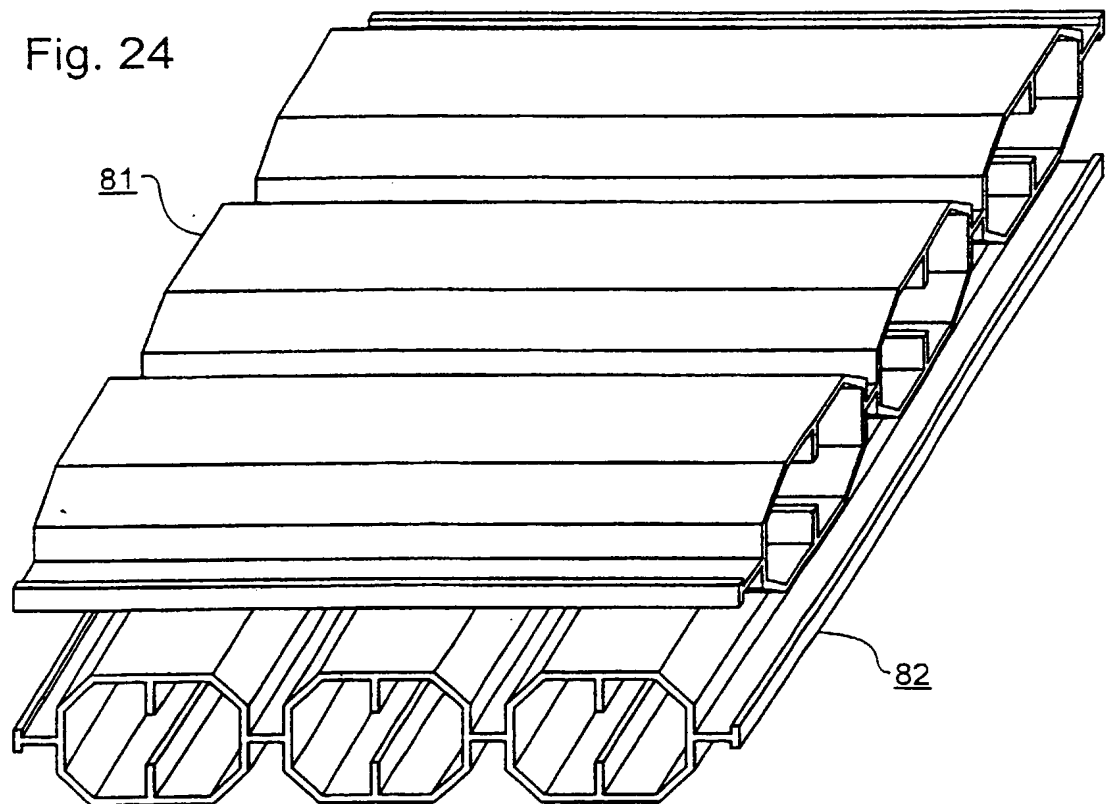


Fig. 24



IMPROVED STRUCTURAL SANDWICH PLATE MEMBERS

The present invention relates to structural sandwich plate members which comprise two outer metal plates and a core of plastics or polymer material bonded to the outer metal plates with sufficient strength to substantially contribute to the structural strength of the member.

Structural sandwich plate members are described in US 5,778,813 and US 6,050,208, which documents are hereby incorporated by reference, and comprise outer metal, e.g. steel, plates bonded together with an intermediate elastomer core, e.g. of unfoamed polyurethane. These sandwich plate systems may be used in many forms of construction to replace stiffened steel plates and greatly simplify the resultant structures, improving strength and structural performance (stiffness, damping characteristics) while saving weight. Further developments of these structural sandwich plate members are described in International Patent Application GB00/04198, also incorporated hereby by reference. As described therein, foam forms may be incorporated in the core layer to reduce weight and transverse metal sheer plates may be added to improve stiffness.

It is an aim of the present invention to provide an alternative arrangement for constructing structural sandwich plate members that are generally lighter weight than such members which have solid plastic or elastomer cores.

According to the present invention there is provided a structural sandwich plate member comprising: first and second outer metal plates; a plastics or polymer core bonded to said outer metal plates with sufficient strength to transfer shear forces therebetween; and a hollow member defining a space within the core free of the core material.

The materials, dimensions and general properties of the outer metal plates of the structural sandwich plate member of the invention may be chosen as desired for the particular use to which the structural sandwich plate member is to be put and in general may be as described in US-5,778,813 and US-6,050,208. Steel is commonly used in thicknesses of 0.5 to 20mm and aluminium may be used where

light weight is desirable. Similarly, the plastics or polymer core may be any suitable material, for example an elastomer such as polyurethane, as described in US-5,778,813 and US-6,050,208.

Preferably, the hollow member is an extruded elongate member, e.g. made of a plastic material such as polyethylene or polypropylene) or, in some cases, a metal such as aluminium. The hollow member may comprise a plurality of elongate tubes joined by webs extending generally parallel to the outer metal plates. The plurality of tubes may be integrally formed with the joining webs or formed as separate items with engaging means provided on the distal ends of the joining webs. Preferably, the joining webs are provided with one or more apertures to improve flow of elastomer during a casting process and to ensure a continuous elastomer connection between the outer plates of the structural sandwich plate member.

The hollow member may also take the form of a plurality of separate elongate tubes held by at least one support member.

The hollow member may be provided with at least one internal reinforcing ribs and/or at least one external ribs for reinforcing and for spacing the hollow member from the outer metal plates (face plates) or through-thickness metal elements of the structural sandwich plate member or from other hollow members included in the structural sandwich plate member. The support member, or the hollow member where no support member is provided, may also provide locating means for receiving one or more reinforcing (shear) plates embedded in the elastomer of the structural sandwich plate member.

The present invention also provides various hollow members for defining voids in a structural sandwich plate member, various end caps for such hollow members and structures constructed with such structural sandwich plate members.

Further, the invention provides a method of manufacturing a structural sandwich plate member comprising the steps of: providing first and second outer metal plates in a spaced apart relationship with a hollow member having an internal space located therebetween; injecting uncured plastics or polymer to fill

the space defined between said outer metal plates save for the internal space of said hollow member; and allowing said plastics or polymer material to cure to bond said outer metal plates together with sufficient strength to transfer shear forces therebetween.

5 The present invention will be described below with reference to exemplary embodiments and the accompanying schematic drawings, in which:

Figure 1 is a cross-sectional view of a hollow member according to a first embodiment of the present invention;

Figure 2 is a perspective view of the hollow member of Figure 1;

10 Figure 3 is a cross-sectional view of a structural sandwich plate member according to the invention incorporating the hollow member of Figure 1;

Figure 4 is a cross-sectional view of a hollow member according to a second embodiment of the present invention;

15 Figure 5 is a cross-sectional view of a structural sandwich plate member according to the invention incorporating a hollow member according to the second embodiment of the invention;

Figure 6 is a cross-sectional view of a support member for supporting hollow members according to a third embodiment of the present invention;

Figure 7 is a perspective view of the support member of Figure 6;

20 Figures 8 to 10 are respectively lateral cross-sectional, longitudinal cross-sectional and perspective views of the hollow member of the third embodiment of the present invention;

Figure 11 is a perpendicular view of the hollow member of the third embodiment with a variant end cap;

25 Figure 12 is a cross-sectional view of a structural sandwich plate member incorporating a hollow member according to the third embodiment and the variant end cap of Figure 11;

30 Figures 13 and 14 are perspective views illustrating the manner of use of the support member and hollow members of the third embodiment of the present invention;

Figures 15, 16 and 17 are lateral cross-sectional views of alternative hollow members according to the third embodiment of the present invention;

Figure 18 is a cross-sectional view of an alternative support member according to the third embodiment of the present invention;

5 Figures 19 and 20 are respectively cross-sectional and perspective views of a hollow member according to a fourth embodiment of the present invention;

Figures 21 and 22 are respectively cross-sectional views of hollow members according to variants of the fourth embodiment of the present invention;

Figure 23 is a cross-sectional view of a structural sandwich plate member
10 including a hollow member according to a fifth embodiment of the invention; and

Figure 24 is a perspective view of an alternative manner of use of hollow members according to the invention.

In the various drawings, like parts are indicated by like references.

15 Embodiment 1

Figures 1 and 2 show in cross-section and in perspective a hollow member 1 according to a first embodiment of the invention which is to be used to define voids in the elastomer core of a structural sandwich plate member 2, as shown in Figure 3. The hollow member 1 exhibits a multiple cell construction with internal
20 reinforcement.

As shown in Figures 1 and 2, the hollow member 1 comprises three elongate tube-like portions 11 joined together by webs 12 to form a flat raft-like structure. Additional webs 13 project from the outer sides of the outer tube-like portions 11 and are terminated by perpendicular flanges 14; these act to space apart
25 adjacent hollow members 1 or to space the hollow member 1 from the edge of a mould in which the structural sandwich plate member is formed or from a through-thickness metal member defining the perimeter of a cell of the structural sandwich plate member. The tube-like portions 11 are, as shown, generally octagonal in form with relatively wide top and bottom faces (as illustrated) and
30 relatively narrow side and corner faces. The tube-like portions 11 are provided

with internal stiffening ribs 15 projecting inwardly from the inner sides of the top and bottom faces. The cross-section of the tube-like portions 11 as well as the size, positioning and number of reinforcing ribs 15 may be varied as desired to provide a desired shape of void in the completed structural sandwich plate member for
5 convenience in manufacturing, and to provide the necessary physical properties of the hollow member.

As can be seen in Figure 2, the joining webs 12 as well as the spacing webs 13 are provided with a plurality of apertures 16, 17; these serve to assist flow of elastomer during manufacture of a structural sandwich plate member and also
10 ensure that there is a continuous elastomer bond between the upper and lower metal plates of the structural sandwich plate member 2.

A completed structural sandwich plate member 2 is shown in section in Figure 3. It can there be seen that the hollow member 1 defines elongate voids in the elastomer core 4 which bonds together the outer metal plates 3. The primary
15 function of the hollow member 1 is to define voids to optimise the location of elastomer to provide an effective lightweight structural sandwich plate member 2 with desired structural performance characteristics. The shape, size, spacing and number of the tube-like portions 11 will therefore be selected according to the cavity plan dimensions and the purpose for which the structural sandwich plate
20 member 2 is to be used to provide the necessary weight saving whilst still providing desired strength and other mechanical properties. Generally, the hollow member 1 does not contribute significantly to the structural strength of the structural sandwich plate member 2. The hollow member 1 and in particular the tube-like portion 11 need only have sufficient strength, determined by the material
25 selected, the shape of the tube-like portions 11 and the reinforcing ribs 15, to resist pressures occurring during injection of the elastomer 4 and to provide support for the upper of metal plates 3 to maintain it at the desired separation then to produce a structural sandwich plate member of desired thickness. The hollow member 11 may therefore be made of a plastics material and have quite thin walls. However,
30 other materials and in particular materials having greater structural strength, such

as aluminium, can be used if desired.

A secondary, optional, function of the hollow member 1 is to allow the passage of conduits, piping, cabling, wiring, ventilation or heating systems and other services, and it may be shaped or constructed with appropriate details to
5 facilitate this function.

To manufacture the structural sandwich plate member 2, the lower of the outer metal plates 3 is welded to internal or perimeter extruded or rolled profiles or to metal framing members. The hollow member 1 is then placed on top, arranged in the desired orientation and connected to couplings if required. The
10 second metal plate is then put in position and welded in place (if required) to form an airtight cavity. In the case of prefabricated moulded structural sandwich plate members the second plate is not welded in place and the edges of the cavity are defined by the mould. Once all the components are in position, uncured elastomer is injected through injection ports (not shown) to fill the space between
15 the lower and upper metal plates 3 and around the hollow member 1. Once the elastomer has cured, the hollow members are made solid with the elastomer to form a lightweight structural composite core. The elastomer will, in general, be injected at an elevated temperature and pressure so that the hollow member 1 must be made of a material with sufficient thermal properties and have sufficient
20 mechanical properties to maintain its shape under the injection conditions. In general the hollow member 1 is not required to maintain its exact shape during the injection procedure; some shrinkage and/or deformation can be permitted provided this is taken into account in determining the amount of elastomer to be injected into the structural sandwich plate member that large distortions of the
25 tube-like portions are avoided and that the void space remains intact.

In the above method of manufacture of the structural sandwich plate member 2, whether prefabricated, made in a mould or in situ, the injection ports and vent holes are generally sealed with metal plugs and ground flush after the elastomer has cured.

Embodiment 2

Figure 4 shows in cross-section part of a hollow member 20 according to a second embodiment of the present invention. This hollow member fulfills the same function as the hollow member 1 of the first embodiment but illustrates some additional features that may be used as desired. For example, the tube-like portions 21a, 21b of the hollow member 20 are of different shapes and the latter is provided with four internal reinforcing ribs 15. Also, the joining webs 22a, 22b between tube-like portions 21a, 21b may be of different widths. Further, the hollow member 20 of Figure 4 includes additional vertical spacing webs 23 projecting from the upper and lower surfaces of the tube-like portions and terminated by flanges 24. The vertical spacing webs 23 serve to space the hollow member 20 away from the outer metal plates 3 during manufacture of the structural sandwich plate member 2, as shown in Figure 5.

Embodiment 3

A third embodiment of the invention is shown in Figures 6 to 18; in the third embodiment the voids are defined by simple elongate tubes which are held in position by support members. The elongate tubes form single-cell hollow members, with or without internal reinforcement.

A support member 30 according to the third embodiment is shown in cross-section and perspective in Figures 6 and 7. The support member 30 comprises three sleeve portions 31 which are sized and shaped to closely receive a hollow tube member. The sleeve portions 31 are spaced apart by webs 33, 34 which also define an upwardly open slot 32. The upper and lower faces of the sleeve portions 31 as well as the outer side faces of the outer ones of the sleeve portions 31 are provided with horizontal and vertical spacing webs 13, 23. As shown more clearly in Figure 6, the support member 30 is relatively short having a length t which may be of the order of 50mm. The support member 30 may conveniently be made by extrusion and cut to length.

A typical hollow tube which fits in the support member 30 is illustrated in

Figures 8 to 10. As can there be seen, the tube has an octagonal cross-sectional form of generally uniform wall thickness with the outer profile matching the inner profile of the sleeve portions 31 of support member 30. The ends of the tube members 60 are in general closed by press-fit sealed end caps 61, though these may
5 be omitted in applications where the tubes will abut and make an adequate seal to side walls of a mould in which the structural sandwich plate member is formed or side walls of a structural sandwich plate member with built-in couplings.

As shown in Figure 11, an alternative form of end cap 61a is fitted with quick connect couplings 61b that extend to and through the perimeter plates,
10 spacers or members of a cavity as illustrated in Figure 12. The quick connect couplings 61b allow easy access to the hollow space for the passing of cabling, wiring, conduits and other services. Special couplings may be included for air ventilation and heating systems. Couplings may be made continuous with the hollow tubes prior to the injection of the elastomer or inserted into drilled holes
15 after injection.

As shown in Figure 13, the hollow tubes 60 are inserted into the sleeve portions 31 of the sleeves 30 which hold the tubes 60 in a parallel spaced apart arrangement. The slots 32 defined in the webs 33, 34 joining the sleeve portions 31 of the support members 30 can accept a vertical metal plate as shown in Figure 14.
20 The resultant assembly is then formed into a structural sandwich plate member in the same manner as described for the first embodiment. In the completed structural sandwich plate member, the vertical plates 5 act as shear plates providing additional stiffness. Note that the shear plates 5 may be perforated and may be welded to one or both of the outer metal plates of the structural sandwich plate
25 member before the elastomer is injected and cured.

It will of course be appreciated that where long tubes are used additional support members may be provided at intervals along them and the tubes may project beyond the ends of the support members. Compared to the first embodiment, the third embodiment may be more versatile since the hollow tube
30 structure (e.g. wall thickness and internal reinforcing) may be varied

independently of the support members. The third embodiment may also have a reduced manufacturing cost since the simple hollow tubes 60 can be manufactured very cheaply.

Variations on the form of hollow tubes 60 are of course possible; some such variations are shown in Figures 15 to 17. As shown in Figure 15, tube 62 includes vertical internal reinforcing ribs 15 extending from the middles of the upper and lower faces of the tube. Tube 63 shown in Figure 16 includes horizontal and vertical reinforcing ribs 64 which meet in the middle of the tube to form a cross. Tube 65 shown in Figure 17 is wider than the tubes 60, 62 and 63 and has a total of eight internal reinforcing ribs, including two extending horizontally from the inner side walls of the tube.

Similarly, variations in the shape of the support member are also possible. One such variation is shown in Figure 18. Other cross-sectional shapes, e.g. square, rectangular, circular, elliptical, for the hollow tube may also be used. The shape and internal structure of the tube may also be chosen dependent upon services which are to be passed through it. Support member 40 shown in Figure 18 differs from support member 30 in that the joining webs 43, 44 extend as continuations of the top and bottom faces of the octagonal sleeve portions 41 so as to define deeper slots 42 for receiving the shear plates 5.

Embodiment 4

A fourth embodiment of the present invention is shown in Figures 19 to 22. The hollow members of the fourth embodiment are single-celled.

In the fourth embodiment, the hollow member 50 comprises a tube-like member, again taking the form in cross-section of an octagon with wider top faces than side faces, with joining webs 52 projecting horizontally from the side faces. The joining webs 52 are terminated with complimentary mating portions 53, 54 by which a plurality of like hollow members placed side-by-side can be engaged. As best seen in Figure 20, the joining webs 52 may be pierced by apertures 55 which perform the same function as the apertures 16 and 17 in the first

embodiment.

Figures 21 and 22 show variants on the hollow member of the fourth embodiment. In the hollow member 50a of Figure 21 the mating portions 53a at the ends of the joining webs 52 are more rounded. In the hollow member 50b of Figure 22 one mating portion 56 defines an elongate groove whilst mating portion 57 defines a complimentary rib.

The hollow members of the fourth embodiment have the advantage that they can be manufactured with a relatively small extrusion die but quickly clipped together to form larger structures for the construction of large structural sandwich plate members.

Mating portions as provided in the fourth embodiment may also be provided on hollow members of the first and second embodiments and support members of the third embodiment. In this way complex structures of hollow members can quickly be built up from components extruded with a simple die. Also, such hollow members can be used in curved panels if the mating portions allow connection at an angle or if the joining webs have some flexibility.

Embodiment 5

Figure 23 illustrates a fifth embodiment of the invention which provides a multi-celled hollow member 70 suitable for use in structural sandwich plate members that have on or more corrugated outer plates.

As can be seen in Figure 23 the hollow member 70 comprises alternate small and large tube-like portions 71, 72. The large tube-like portions 72 have a cross-section in the form of an irregular polygon shaped to fit in the space defined by the outwardly projecting parts of the corrugated lower weld plate 3a. The small tube-like portions 71 are flatter in cross-section to fit between the inwardly projecting parts of the corrugated lower metal plate 3b and flat upper plate 3.

The large tube-like portions 72 are provided with reinforcing ribs 73, 74. Reinforcing ribs 73 extend a short distance inwardly from the large faces of the large tube-like portions 72 whilst reinforcing ribs 74 extend from the smaller faces

to meet in a Y-formation. The small tube-like portions 71 are, in this case, not provided with reinforcing ribs but such ribs can be provided if desired. Both large and small tube-like portions 71, 72 are provided with spacers 75.

The hollow member 70 may be extruded as a single multi-celled unit, as shown, or assembled from smaller units, e.g. single- or two-celled, connected together by mating portions as provided in the fourth embodiment.

Whilst we have described above preferred embodiments of the present invention it will be understood that modifications and variations to these may be made without departing from the scope of the invention, which is defined by the appended claims. It will also be appreciated that multiple layers of hollow members may be used in a simple structural sandwich plate member. The hollow members 81, 82 of different layers in such an arrangement may be arranged perpendicularly, as shown in Figure 24, or at other angles.

Whilst the hollow members described above are formed by extrusion, this is not essential. For example, the hollow members could be formed from thermosetting plastic sheets bonded together to form a complex, multi-celled waffle voided structure to define elastomer ribs in two directions. Also, the hollow members may be formed as spheres (or other void shapes) which are loosely or tightly packed into the cavity of the structural sandwich plate member. Elastomer would then be injected to fill the interstices between the spheres. If the spheres are loosely packed spacers or a spacer frame may be used. The spheres may be all the same size or of varying sizes.

CLAIMS

1. A structural sandwich plate member comprising: first and second outer
5 metal plates; a plastics or polymer core bonded to said outer metal plates with
sufficient strength to transfer shear forces therebetween; and a hollow member
defining a space in the core free of the core material.
2. A structural sandwich plate member according to claim 1 wherein the
10 hollow member is an extruded elongate member.
3. A structural sandwich plate member according to claim 2 wherein the
hollow member comprises a plurality of elongate tubes joined by webs extending
generally parallel to the outer metal plates.
15
4. A structural sandwich plate member according to claim 3 wherein said
plurality of tubes are integrally formed with the joining webs as a single unit.
5. A structural sandwich plate member according to claim 3 wherein each of
20 said plurality of tubes is formed as a separate item having at least one projecting
joining web provided at its distal ends with engaging means.
6. A structural sandwich plate member according to claim 3, 4 or 5, wherein
said plurality of tubes comprises tubes of at least two different shapes or sizes.
25
7. A structural sandwich plate member according to any one of claims 3, 4, 5
or 6 wherein said joining webs are provided with a plurality of apertures.
8. A structural sandwich plate member according to claim 1 wherein the
30 hollow member comprises a plurality of separate elongate tubes and at least one

support member for holding said elongate tube in a spaced apart arrangement.

9. A structural sandwich plate member according to any one of the preceding
claims wherein the hollow member is provided with at least one internal
5 reinforcing ribs.

10. A structural sandwich plate member according to any one of the preceding
claims wherein said hollow member is provided with at least one external rib for
reinforcing and/or spacing the hollow member from the outer metal plates of the
10 structural sandwich plate member or from other hollow members included in the
structural sandwich plate member.

11. A structural sandwich plate member according to any one of the preceding
claims wherein said hollow member is provided with support means for receiving
15 and locating at least one reinforcing plate.

12. A structural sandwich plate member according to any one of the preceding
claims comprising at least two layers of hollow members.

20 13. A structural sandwich plate member according to any one of the preceding
claims wherein the core is made of an elastomer.

14. A hollow member to be disposed within a structural sandwich plate
member comprising first and second outer metal plates and a plastics or polymer
25 core bonded to said outer metal plates with sufficient strength to transfer shear
forces therebetween; said hollow member defining a space within the core free of
the core material.

15. A method of manufacturing a structural sandwich plate member
30 comprising the steps of: providing first and second outer metal plates in a spaced

apart relationship with a hollow member having an internal space located therebetween; injecting uncured plastics or polymer to fill the space defined between said outer metal plates save for the internal space of said hollow member; and allowing said plastics or polymer to cure to bond said outer metal plates
5 together with sufficient strength to transfer shear forces therebetween.

16. A structural sandwich plate member constructed substantially as hereinbefore described with reference to the accompanying drawings.

10 17. A hollow member for a structural sandwich plate member substantially as hereinbefore described with reference to the accompanying drawings.



INVESTOR IN PEOPLE

Application No: GB 0108203.1
Claims searched: 1 to 17

Examiner: R.J.MIRAMS
Date of search: 21 September 2001

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): B5N

Int Cl (Ed.7): B29C. B32B 3/08, 3/20, 3/26, 3/30, 15/06, 15/08, 15/16.

Other: ONLINE: WPI, EPODOC, JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X,E	GB2355957 (INTELLIGENT ENGINEERING) e.g. page 4 line 33 to page 5 line 1	at least 1 to 4, 8, 10 and 13 to 15
X	WO81/03640A1 (STAFFENTREPRISER) whole document	at least 1, 2, 8, 10, 11, 14 and 15
X	DE3123134A1 (GÜNTER HOFF) e.g. page 4 line 10 to page 5 line 8	at least 1, 12, 14 and 15

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A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

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